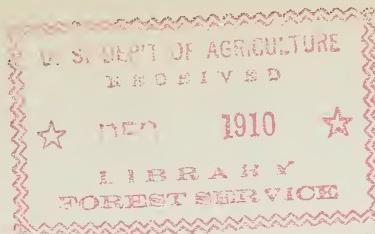


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GRAPE-SPRAYING EXPERIMENTS IN MICHIGAN IN 1909.

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INTRODUCTION.

Black-rot of the grape, which is caused by the fungus *Guignardia bidwellii* (Ell.) V. & R., is without doubt the most destructive fungous disease of grapes in the eastern United States. Its first appearance in the spring is usually in the form of brown spots on the leaves, upon which a number of small black pustules may soon be seen. These contain one kind of spores by means of which the fungus is reproduced, sometimes called summer spores. These minute rounded bodies are scattered chiefly by wind and rain. When under favorable conditions one alights on the leaves, young shoots, stems of bunches of grapes, or the berries themselves, it sends out a tube which may penetrate and destroy the tissue. The result of the infection of the berries is usually first evident as a whitish spot on the surface. This is soon surrounded by a light-brown area, which gets darker as the disease progresses. The grape meanwhile shrivels up and finally becomes dark and mummied and covered with the black pustules containing the spores.

There is also a form of spores called winter spores, which grow in black pustules similar to those described above. These are very common on the old mummied grapes in the spring and summer, and are a very efficient means of reproducing and distributing the fungus. In favorable weather the disease spreads rapidly and does an immense amount of damage. In a hot season with frequent rains it is not uncommon to see the entire crop of a heavily laden vineyard totally destroyed or so badly damaged that the grapes would not pay for the labor involved in harvesting.

During the early years of the industry in the principal grape-growing region of Michigan, located around Lawton and Paw Paw, very little was known of black-rot. The grape districts of New Jersey, Pennsylvania, New York, and Ohio all suffered severely at times during this period from this destructive parasite, but the Michigan vineyards were comparatively free from it. As the farmers learned that this locality was better adapted to the raising of grapes than to general farming more vineyards were set until grape growing became the principal industry. The acreage of grapes increased and

vineyards extended in almost solid blocks for miles. At the same time the fungi parasitic upon this fruit became more widely distributed and firmly established. This was the condition about 1905, which was the beginning of a series of wet seasons very favorable for the development of most fungous diseases and especially black-rot.

In the season of 1906 considerable damage was done in certain parts of the grape district and some of the growers became rather discouraged over the outlook. Some vineyards did not suffer from the disease, while in others the crop was not worth harvesting. A few of the growers endeavored to control the disease by spraying, and in some cases their efforts met with partial success. Very little was done, however, toward fighting the disease, as many of the vineyardists were of the opinion that the trouble was only temporary and did not wish to go to the expense of buying machinery and preparing to spray for one season. They hoped that the next few seasons would be less favorable for rot and the injury from the disease would cease to be important. Such, however, was not the case.

The next year, 1907, demonstration work on the control of the disease and spraying experiments to determine the comparative value of various spray mixtures were begun by the Bureau of Plant Industry of the United States Department of Agriculture. This work was taken up in accordance with an understanding with the State Agricultural Experiment Station at Lansing. It was carried on through the seasons of 1907 and 1908, as reported in a previous publication of this Bureau,^a and continued in 1909 under the immediate direction of Dr. C. L. Shear, as described in the following pages.

THE DISEASE IN 1909 AND EXPERIMENTS TO CONTROL IT.

The weather during the season of 1909 was very favorable for black-rot. Frequent rains with intervals of warm, humid weather furnished excellent conditions for the development and distribution of the spores. The first evidences of the disease on the young growth were noted on June 11, when leaves with the characteristic brown spots bearing the fruiting bodies of the fungus were found. By June 24 considerable damage had been done in unsprayed and poorly sprayed vineyards by the rot on the stems of the blossom clusters, peduncles of the flower buds, and calyxes of the unopened flowers. Whole bunches were destroyed in this way, the fungus causing the buds to shrivel and dry up. (See Pl. I, fig. 1, A.) Thus in some cases a considerable portion of the crop was destroyed before the flowers opened, while the properly sprayed fruit was unharmed. (See Pl.

^a See "The Control of Black-Rot of the Grape," Bulletin 155, Bureau of Plant Industry, U. S. Dept. of Agriculture, pp. 24-35.



FIG. 1.—*A*, TWO BUNCHES OF GRAPE BLOSSOMS FROM AN UNSPRAYED CHECK PLAT IN MR. TUTTLE'S VINEYARD, NEAR PAW PAW, MICH., ALMOST ENTIRELY DESTROYED BY ROT BEFORE BLOSSOMING. *B*, A BUNCH OF SPRAYED GRAPES FROM THE SAME VINEYARD SHOWING NO DAMAGE FROM ROT.

[Natural size.]



FIG. 2.—*A*, AN AVERAGE BUNCH OF GRAPES, SHOWING THE PROPORTION OF ROTTEN BERRIES (90.7 PER CENT) IN THE UNSPRAYED CHECK PLAT IN THE TUTTLE VINEYARD. *B*, AN AVERAGE BUNCH OF GRAPES, SHOWING THE PROPORTION OF ROTTEN BERRIES (4.3 PER CENT) IN PLAT 14 IN THE SAME VINEYARD.

[Three-fourths natural size.]



I, fig. 2, *B.*) Rot appeared on the young berries on July 5, and from that date until the grapes were harvested there were only a few brief periods that one could not find black-rot in all stages of development on the fruit. The latest that it was seen developing on the leaves was September 29, when fresh spots were found rather abundantly on the younger leaves.

EXPERIMENTS.

The spraying experiments for the control of black-rot were carried on in 1909 in the same general way as in previous years. A number of different mixtures were used on separate plats in the vineyards in which work was done, in order to determine their comparative value as fungicides, as follows:

(1) Bordeaux mixture, prepared with commercial copper sulphate, fresh stone lime, and water, in the order given, was used according to the following formulas: ^a 4-4-50; 4-3-50; 4-2-50; 3-2-50.

(2) Neutral copper acetate, prepared by dissolving 1 pound of neutral copper acetate in 50 gallons of water.

(3) Ammoniacal copper carbonate, prepared by dissolving 6 ounces of copper carbonate in 3 pints of strong ammonia and adding it to 50 gallons of water.

(4) Self-boiled lime-sulphur, prepared by putting 10 pounds of fresh stone lime in a barrel and adding a little cold water; then 10 pounds of sulphur, and enough water to slake the lime into a paste. After the lime had slaked, the mixture was diluted to 50 gallons.

(5) Commercial lime-sulphur, prepared by mixing 1 gallon of commercial lime-sulphur wash with 75 gallons of water.

The two vineyards in which the work was done were the David Engel vineyard, near Paw Paw, recently leased by Mr. Roy L. Tuttle, in cooperation with whom the work was carried on, and the C. C. Giddings vineyard, near Lawton, which was one of the vineyards used in the experiments conducted in 1908.

THE EXPERIMENTS IN MR. GIDDINGS'S VINEYARD, NEAR LAWTON, MICH.

The vineyard of Mr. Giddings contains Concord vines trained after the Kniffen system. The plats were about one-third of an acre in area. The check of the previous year ^b was used, which furnishes some data upon the effect of spraying the same vines for two successive years as compared with allowing the grapes to go unsprayed for that length of time. The mixtures were applied with the same geared

^a In writing formulas for Bordeaux mixture, the quantity of copper sulphate is given first, lime second, and water last: for example, 3-2-50 Bordeaux mixture means 3 pounds of copper sulphate, 2 pounds of lime, and enough water to make 50 gallons of the mixture.

^b See "The Control of Black-Rot of the Grape," Bulletin 155, Bureau of Plant Industry, U. S. Dept. of Agriculture.

traction sprayer as before, with fixed nozzles for the first three sprayings and trailers manipulated by hand for the last two. Plat 5 was the check and was not sprayed. The mixtures used and the treatment given the plats were as follows:

TABLE I.—*Dates of spraying and fungicides used on nine experimental plats of Concord grapes in Mr. Giddings's vineyard, near Lawton, Mich., 1909.*

Date of spraying.	Fungicide used.	Stage of growth.
PLAT 1.		
May 28	4-4-50 Bordeaux mixture.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	.....do.....	Do.
PLAT 2.		
May 28	4-3-50 Bordeaux mixture.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	.....do.....	Do.
PLAT 3.		
May 28	4-3-50 Bordeaux mixture, with 2 pounds of iron sulphate.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	.....do.....	Do.
PLAT 4.		
May 28	4-2-50 Bordeaux mixture.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	.....do.....	Do.
PLAT 6.		
May 29	3-2-50 Bordeaux mixture.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	.....do.....	Do.
PLAT 7.		
May 29	Ammoniacal solution of copper carbonate.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	.....do.....	Do.
PLAT 8.		
May 29	Neutral copper acetate.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	.....do.....	Do.
PLAT 9.		
May 29	Self-boiled lime-sulphur.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	Neutral copper acetate.....	Do.
PLAT 10.		
May 29	Commercial lime-sulphur.....	Shoots 6 to 12 inches long.
June 8	.....do.....	Nearly ready to blossom.
30	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
July 10	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
21	Neutral copper acetate.....	Do.

Counts were made of the total number of berries on 1,000 average bunches in the vineyard and of the rotten berries on 1,000 average bunches in each plat. The percentage of rot was computed from these data. It has been noticed that in grapes trained on the Kniffen system the fruit on the lower wire seems more susceptible to rot than that above. In order to get more accurate data on this subject counts were made in the check on the two wires separately. The following table shows the percentage of rot on the different plats:

TABLE II.—*Results of spraying experiments on nine plats of Concord grapes in Mr. Giddings's vineyard, near Lawton, Mich., 1909.*

No. of plat.	Number of applications.	Fungicide used.	Amount of rot. Per cent.
1	5	4-4-50 Bordeaux mixture.....	0.10
2	5	4-3-50 Bordeaux mixture.....	.10
3	5	4-3-50 Bordeaux mixture, with 2 pounds of iron sulphate.....	.10
4	5	4-2-50 Bordeaux mixture.....	.10
5	None.	Check, unsprayed, upper wire, 34.3 per cent; check, unsprayed, lower wire, 45.4 per cent.....	39.85
6	5	3-2-50 Bordeaux mixture.....	.03
7	5	Ammoniacal copper carbonate.....	2.60
8	5	Neutral copper acetate.....	.48
9	5	Self-boiled lime-sulphur.....	2.30
10	5	Commercial lime-sulphur.....	.84

Neutral copper acetate was used in the fifth spraying on plats 9 and 10, the others being sprayed as before.

There was a heavy snowstorm accompanied by a freeze before all the grapes were picked, and a considerable quantity of the fruit on all the plats but the check was frozen. It is therefore impossible to compare the yields of the different plats. This, however, is unimportant, as it has been found that individual vines vary greatly in their productiveness and the most accurate method of determining the amount of rot is by counting. The contrast between the condition of the fruit in the check and the sprayed plats was quite striking, and there was a marked difference between the amount of rot on the upper and lower wires of the check. It is possible that a system of high-arm pruning might be practiced which would give better ventilation under the vines and allow them to dry off more quickly. However, more observations are needed on this point.

The grapes in the check were so badly injured by rot that it was impracticable to attempt to market them except in bulk, the cost of the labor required in separating the few good bunches from the rotten fruit being more than the difference in price between wine and table grapes. On the other hand the rot in the plats sprayed with the different strengths of Bordeaux mixture was practically

negligible and there was no injury to the foliage. This was, however, not the case with some of the other mixtures.

Neutral copper acetate used on plat 8 throughout the season burned the leaves to some extent, while the foliage in plat 10, sprayed with commercial lime-sulphur, was not in good condition. The ammoniacal solution of copper carbonate and the self-boiled lime-sulphur did not seem to brown the leaves, but the injury from rot was greater than in the other sprayed plats. However, the amount of rot on all the sprayed plats was so small that it is hardly possible to get more than an indication of the comparative value of the different mixtures.

THE EXPERIMENTS IN MR. TUTTLE'S VINEYARD, NEAR PAW PAW, MICH.

The experiments near Paw Paw, Mich., as has been said, were carried on in a vineyard recently leased by Mr. Tuttle. It comprises about 11 acres of Concord vines of good bearing age, together with some mixed varieties. It had never been thoroughly sprayed and had not received proper cultivation for several years. This was not remarkable, for since 1906 the crop had been almost destroyed each season by black-rot, and hardly enough fruit had been produced to pay for the harvesting. The receipts from the crops for the three years previous to 1909 were as follows:

Year.	Gross receipts.	Cost of harvesting and baskets.	Net receipts.
1906.....	\$8.82	(a)	(a)
1907.....	70.70	(a)	(a)
1908.....	250.56	\$176.13	\$74.43

^a Not known.

The cost of harvesting for 1906 and 1907, which is not known, would undoubtedly reduce the returns considerably. When the cost of pruning, tying, and cultivation for 11 acres of vineyard is deducted from the above returns it leaves a rather insignificant amount, to say the least, as net profit. Counts were made in this vineyard in 1908 of good and rotten berries on a large number of average bunches and the rot was found to be 58 per cent of the total.

The experiments in this vineyard were taken up to demonstrate that the disease can be controlled by good cultivation and spraying even after the black-rot has become thoroughly established. The vineyard was given careful and thorough cultivation by Mr. Tuttle. Fourteen plats were laid out, thirteen of which were sprayed, each plat being one-half acre in area except the check, which was three-eighths of an acre. A geared traction sprayer was used, similar to that of Mr. Giddings, with fixed nozzles for the first three applica-

tions and trailers manipulated by hand for the additional ones. Plat 6 was the check and was not sprayed, though cultivated the same as the rest. The treatment given the different plats was as follows:

TABLE III.—*Dates of spraying and fungicides used on thirteen experimental plats in Mr. Tuttle's vineyard, near Paw Paw, Mich., 1909.*

Date of spraying.	Fungicide used.	Stage of growth.
PLAT 1.		
June 1	4-4-50 Bordeaux mixture.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
24	.....do.....	Do.
Aug. 6	Neutral copper acetate.....	Grapes about $\frac{5}{8}$ inch in diameter.
PLAT 2.		
June 1	4-3-50 Bordeaux mixture.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
24	.....do.....	Do.
Aug. 6	Neutral copper acetate.....	Grapes about $\frac{5}{8}$ inch in diameter.
PLAT 3.		
June 2	4-3-50 Bordeaux mixture, with 2 pounds of iron sulphate.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
24	.....do.....	Do.
Aug. 6	Neutral copper acetate.....	Grapes about $\frac{5}{8}$ inch in diameter.
PLAT 4.		
June 1	4-3-50 Bordeaux mixture, with 2 pounds of soap.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
24	Without soap.....	Do.
Aug. 6	Neutral copper acetate.....	Grapes about $\frac{5}{8}$ inch in diameter.
PLAT 5.		
June 2	4-2-50 Bordeaux mixture.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
24	.....do.....	Do.
Aug. 6	Neutral copper acetate.....	Grapes about $\frac{5}{8}$ inch in diameter.
PLAT 7.		
June 2	3-2-50 Bordeaux mixture.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
26	.....do.....	Do.
Aug. 6	Neutral copper acetate.....	Grapes about $\frac{5}{8}$ inch in diameter.
PLAT 8.		
June 2	Ammoniacal solution of copper carbonate.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{3}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
26	.....do.....	Do.
Aug. 6	.....do.....	Grapes about $\frac{5}{8}$ inch in diameter.

TABLE III.—*Dates of spraying and fungicides used on thirteen experimental plats in Mr. Tuttle's vineyard, near Pigeon, Mich., 1909—Continued.*

Date of spray-ing.	Fungicide used.	Stage of growth.
PLAT 9.		
June 2	Neutral copper acetate.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 5	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
26	.....do.....	Do.
Aug. 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
PLAT 10.		
June 3	Self-boiled lime-sulphur.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
29	.....do.....	Just out of blossom.
July 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
26	Neutral copper acetate.....	Do.
Aug. 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
PLAT 11.		
June 3	Commercial lime-sulphur.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
28	.....do.....	Just out of blossom.
July 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
14	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
26	Neutral copper acetate.....	Do.
Aug. 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
PLAT 12.		
June 3	4-3-50 Bordeaux mixture.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
30	.....do.....	Just out of blossom.
July 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
15	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
26	.....do.....	Do.
Aug. 6	Neutral copper acetate.....	Grapes about $\frac{1}{8}$ inch in diameter.
PLAT 13.		
June 3	4-3-50 Bordeaux mixture.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
30	.....do.....	Just out of blossom.
July 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
15	.....do.....	Grapes about $\frac{1}{2}$ inch in diameter.
PLAT 14.		
June 3	4-3-50 Bordeaux mixture.....	Shoots 8 to 16 inches long.
11	.....do.....	Nearly ready to blossom.
30	.....do.....	Just out of blossom.
July 6	.....do.....	Grapes about $\frac{1}{8}$ inch in diameter.
15	4-3-50 Bordeaux mixture, with 2 pounds of soap.....	Grapes about $\frac{1}{2}$ inch in diameter.

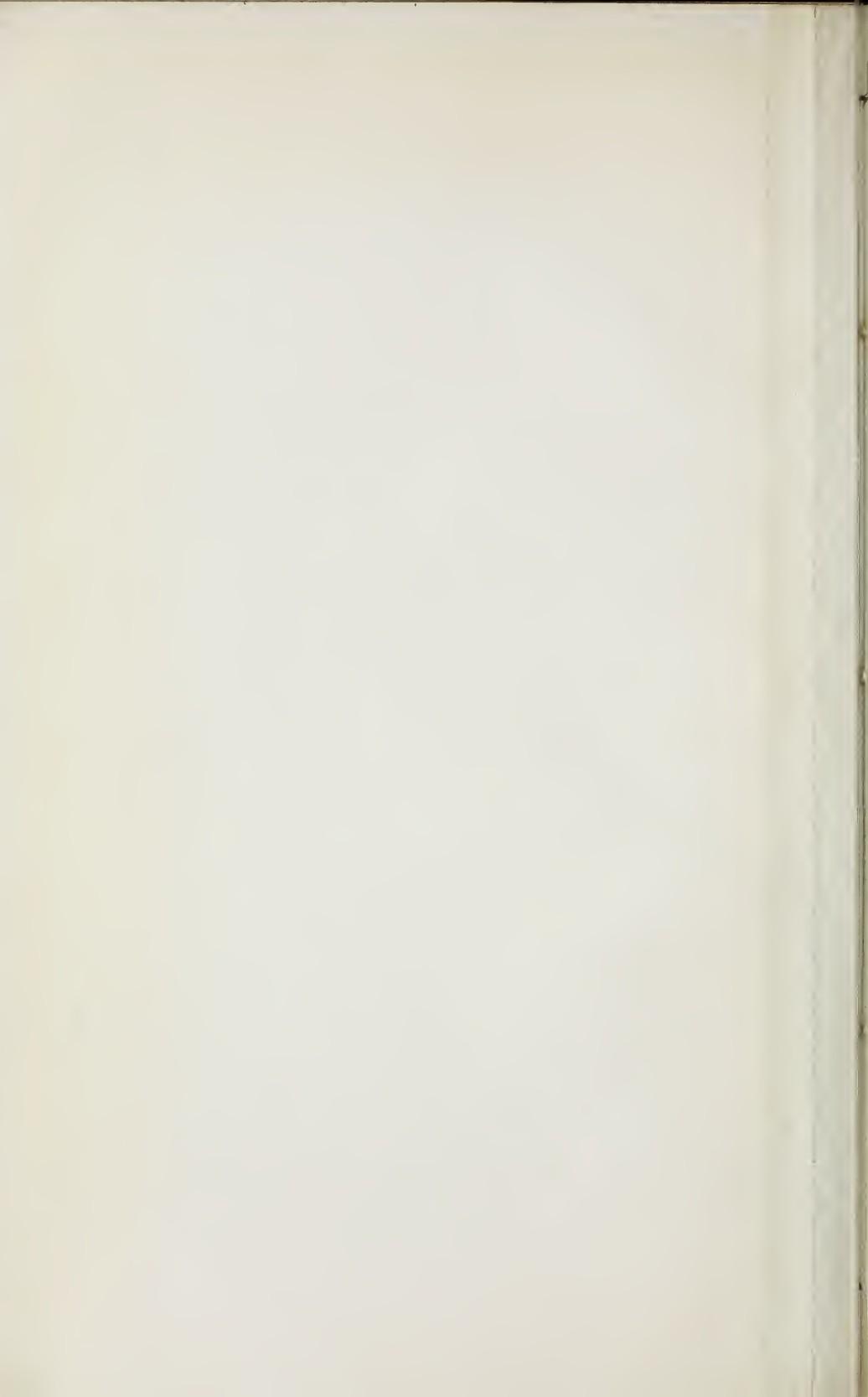
Counts were made of the berries on 2,000 average bunches in this vineyard; also of the good berries on 1,000 average bunches in each sprayed plat and 2,000 bunches in the check plat. The amount of rot was computed from these data. In the check plat the percentage of rot on a row next to a sprayed plat was found and also on a row in the middle of the plat, in order to determine whether in spraying one row the mixture would be carried over to the next enough to influence the amount of rot on it. The percentage of rot, however, was found to be greater on the outside row next the sprayed plat than on the one in the middle. This would indicate that the error in this



FIG. 1.—PORTION OF A VINE IN PLAT 14 IN MR. TUTTLE'S VINEYARD, NEAR PAW PAW, MICH., SPRAYED WITH 4-3-50 BORDEAUX MIXTURE. SOME LEAVES HAVE BEEN REMOVED.



FIG. 2.—PORTION OF A VINE IN THE UNSPRAYED CHECK PLAT IN THE VINEYARD SHOWN IN FIGURE 1. SOME LEAVES HAVE BEEN REMOVED.



system of plats caused by the blowing or carrying over of a fungicide from one plat to another is negligible. However, the counts to get the percentage of rot on each plat were made on the inner rows, while in getting the average number of berries on a bunch counts were made on all the rows.

The percentage of rot on the different plats was as follows:

TABLE IV.—*Results of spraying experiments on thirteen plats in Mr. Tuttle's vineyard, near Paw Paw, Mich., 1909.*

No. of plat.	Number of applica- tions.	Fungicide used.	Amount of rot.	Yield in baskets.	
				8 pounds.	20 pounds.
1	7	4-4-50 Bordeaux mixture.....	35.0	105	18
2	7	4-3-50 Bordeaux mixture.....	40.0	101	27
3	7	4-3-50 Bordeaux mixture, with 2 pounds of iron sulphate.....	40.7	97	25
4	7	4-3-50 Bordeaux mixture, with 2 pounds of resin-fishoil soap for 5 applications.....	35.0	85	21
5	7	4-2-50 Bordeaux mixture.....	37.2	90	16
6	None.	Check, unsprayed, outer row 91.2 per cent.			
6	None.	Check, unsprayed, middle row 90.2 per cent.....	90.7	None.	None.
7	7	3-2-50 Bordeaux mixture.....	38.4	108	21
8	7	Ammoniacal copper carbonate.....	72.4	None.	24
9	7	Neutral copper acetate.....	40.1	None.	49
10	7	Self-boiled lime-sulphur.....	54.3	None.	33
11	7	Commercial lime-sulphur.....	45.2	20	13
12	7	4-3-50 Bordeaux mixture.....	8.0	205	8
13	5	4-3-50 Bordeaux mixture.....	10.9	210	5
14	5	4-3-50 Bordeaux mixture, with 2 pounds of soap in fifth application.....	4.3	210	5

Neutral copper acetate was used in the sixth spraying on plats 10 and 11 and in the seventh application on all plats sprayed at that time except No. 8.

Many of the buds were destroyed by climbing cutworms in the early spring before they opened. This, together with the poor condition of the vineyard, is probably the reason for the light crop. In this vineyard, as in that of Mr. Giddings, the various Bordeaux mixtures proved to be the most efficient, and there was no injury to the vines and not so much damage from rot in most cases as with the other fungicides. In the first six plats sprayed with Bordeaux mixtures there was very little difference in the amount of rot. The addition of iron sulphate as a "sticker" did not seem to improve the mixture, as the percentage of rot on this plat was the highest of any sprayed with Bordeaux mixture, while in the case of plat 4, where resin-fishoil soap was used as an adhesive, the grapes were in slightly better condition. However, the iron sulphate has been used only one season and should be more thoroughly tested before it is abandoned. The 3-2-50 Bordeaux mixture compares very favorably with the others, as it did on Mr. Giddings's vineyard.

In plats 12 to 14, sprayed with Bordeaux mixture, there was not much damage from rot. These were on the opposite side of the

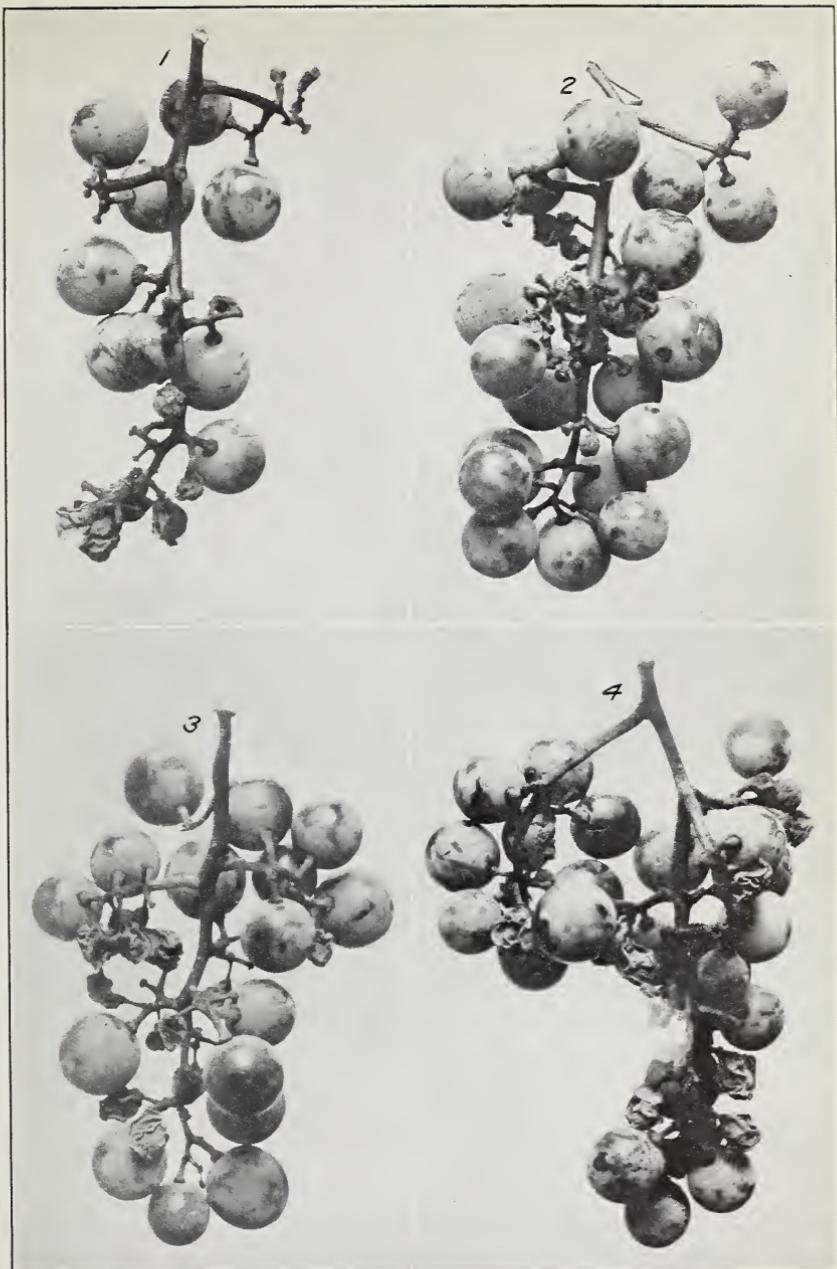
vineyard from the other plats sprayed with this fungicide and can hardly be compared with them, as the disease seemed to be more easily controlled here. They were not far from the check, however, and there is no apparent reason to doubt that but for the spraying the grapes would have been as badly damaged as on plat 6. In the three plats, No. 14, sprayed five times with 4-3-50 Bordeaux mixture, 2 pounds of resin-fishoil soap being added the last time, was in the best condition. No. 12, sprayed seven times, and No. 13, sprayed five times with the same mixture without the soap, suffered somewhat more damage from the rot.

These results would indicate that it may not be necessary to spray more than five times when soap is added at the last spraying to make the mixture spread out and adhere more closely to the berries. More work is necessary to determine this point, however. With the other spray mixtures the results were not equal to those with the Bordeaux mixture, as may be seen in Plates I and III.

Of the two nonstaining compounds used throughout the season for comparison, the neutral copper acetate seemed to be the most effective fungicide. It, however, injured the vines considerably, in some cases almost entirely defoliating them; consequently the fruit was small and stunted, as shown in Plate III, figure 2, and did not ripen well. It was sold as a poor grade of wine grape. Used as a non-staining compound in the last spraying, the neutral copper acetate seemed to have no ill effects. In the plat sprayed with ammoniacal copper carbonate there was no injury to the foliage, but the damage from rot was very great, as shown in Plate III, figure 1. Only a few 20-pound baskets of wine grapes could be picked from this plat.

The lime-sulphur mixtures can hardly be considered good fungicides for use on grapes. In the case of the self-boiled lime-sulphur there was little injury to the foliage but a high percentage of rot, as may be seen in Plate III, figure 3, and what few grapes survived were sold in bulk. In the case of the commercial lime-sulphur the rot was not controlled as well as by the Bordeaux mixture and the vines were badly damaged. The growth of foliage was much less than in the other plats, the leaves were small and browned, the shoots were short, and the bunches of fruit were much undersized, ragged, and poorly ripened. (See Pl. III, fig. 4.) Twenty 8-pound baskets were all the marketable grapes harvested from the plat, the rest being sold in bulk. The crop was not only badly injured for that season, but the canes for the next season's crop were small and in poor condition. Grape foliage seems to be extremely susceptible to injury from this fungicide.

A comparison of the grapes of the check with those of plat 14, as shown in Plate I, figure 2, and Plate II, figures 1 and 2, gives us a sharp contrast. In the check we have a loss of 90.7 per cent, as



AVERAGE BUNCHES OF GRAPES, SHOWING THE PROPORTION OF GOOD AND ROTTEN BERRIES IN FOUR PLATS IN MR. TUTTLE'S VINEYARD, NEAR PAW PAW, MICH.

FIG. 1.—Bunch from plat 8 sprayed seven times with ammoniacal copper carbonate. FIG. 2.—Bunch from plat 9 sprayed seven times with neutral copper acetate. FIG. 3.—Bunch from plat 10 sprayed five times with self-boiled lime-sulphur and twice with neutral copperacetate. FIG. 4.—Bunch from plat 11 sprayed five times with commercial lime-sulphur and twice with neutral copper acetate.

[Reduced to three-fourths natural size.]



shown in Plate I, figure 2, A, while in the other plat there were 4.3 per cent of the grapes destroyed by rot (see Pl. I, fig. 2, B), giving a difference of 86.4 per cent as the value of spraying. Practically the difference was 95.7 per cent, as none of the grapes on the check were harvested. The cost of spraying per acre in 1909 was found to be as follows:

TABLE V.—*Cost of spraying 1 acre with 4-3-50 Bordeaux mixture, 125 gallons being applied.*

Copper sulphate, 10 pounds, at 5½ cents	\$0.55
Lime, 7½ pounds, at two-thirds cent	.05
Man and team, one hour, at 35 cents	.35
Total cost of one application with fixed nozzles	\$0.95
When trailers are used:	
Two men to carry trailers, at 15 cents	.30
Total cost of one application when trailers are used	1.25
Cost of five applications:	
Three applications with fixed nozzles, at 95 cents	2.85
Two applications with trailers, at \$1.25	2.50
Total cost of five applications to 1 acre, three with fixed nozzles and two with trailers	5.35

GENERAL CONCLUSION.

In comparing the results with the different formulas for Bordeaux mixture used there seems to be very little to choose. There was practically no difference in their fungicidal value in Mr. Giddings's vineyard, while in Mr. Tuttle's the percentage of difference, though considerably greater, was not particularly striking.

The plats sprayed with 4-3-50 Bordeaux mixture with soap added gave the lowest percentage of rot, and this mixture is probably the best for general use. The results with the 3-2-50 formula, however, were very good, and it is possible that it is as good a fungicide as any of the other mixtures. The addition of soap in the last spraying only considerably reduces the expense and seems as efficient as where it is used all through the season. Soap should not be added later than July 15 where the season is like that of Michigan. The use of soap at later dates is liable to injure the sale of the fruit, as the mixture is very adhesive, and if the latter part of the season is dry it will still be on the grapes when they are picked.

In view of the results of the work of the season of 1909 and of the previous two years, the recommendations for spraying in Michigan are as follows:

First application, when the shoots are from 8 to 16 inches long, using 4-3-50 Bordeaux mixture to cover the young growth before it becomes infected.

Second application, just before blossoming or as near blossoming time as possible, using the same fungicide. This is to cover the leaves which have recently come out, as well as the clusters of young blossom buds.

Third application, just as the blossoms fall, when the fruit is setting. This, when properly done, covers the young fruit and protects it from the disease.

The fourth application should be from one to two weeks after the third, depending on the weather. If it is hot, with frequent rains, the spraying should not be delayed more than one week, while if there is very little rain the interval might be lengthened to ten days or two weeks.

The fifth application should be about ten days after the fourth, using 4-3-50 Bordeaux mixture, as in all previous sprayings, with the addition of 2 pounds of resin-fishoil soap. The soap should, however, not be used after July 15.

Fixed nozzles may be used in the first three sprayings, but it is much better to use trailers or long hose with nozzles directed by hand in the last two. The foliage is heavy by the time for the fourth application and it is impossible to cover the young grapes properly with fixed nozzles. In the case of a vineyard which has been thoroughly sprayed for some seasons and where there is but a small amount of rot present, it would probably be unnecessary to spray more than three times in a dry season. These applications should correspond to the first three given in the foregoing outline. When it is deemed necessary to spray after July 15, a nonstaining compound should be used. For this purpose neutral copper acetate, 1 pound to 50 gallons, is the best mixture tested in these experiments.

In making Bordeaux mixture, good stone lime should be used whenever possible and the mixture should be prepared as described in Farmers' Bulletin 284. Thoroughness in application can hardly be too strongly emphasized. The mixture should be applied at the rate of 125 gallons to the acre and under a pressure of 100 to 125 pounds. Some good nozzle that will make a fine mist-like spray should be used. All portions of the vine should be covered. After the fruit sets it should receive special attention, and an effort should be made to cover the berries as thoroughly as possible. Much of the indifferent success in spraying is due to carelessness in the mixing and lack of thoroughness in the application.

SUMMARY.

The work in 1909 has shown that black-rot can be controlled by proper methods of spraying and cultivation even in a season particularly favorable for the development of the disease and in a vineyard

in which the fungus has become thoroughly established and very destructive, there being a difference of 86.4 per cent between the amount of rot on the unsprayed check and the best sprayed plat.

In Mr. Giddings's vineyard, which had been thoroughly sprayed the previous year, there was practically no loss from black-rot on the portions sprayed with Bordeaux mixture, while the loss on the check was 39.8 per cent.

The best fungicide used was Bordeaux mixture, and of the different formulas for this the 4-3-50 has always given good results. The 3-2-50 mixture gives promise of being a good fungicide, as about the same results were obtained with it as with the 4-3-50 formula. It may prove as efficient as the 4-3-50 formula, but should be tested more thoroughly.

Of the two nonstaining compounds used, neutral copper acetate and ammoniacal copper carbonate, the former was found to be the better fungicide. For comparison, see Plate III, figures 1 and 2. It, however, injured the foliage badly when used throughout the season, but seemed to have no ill effect as a final application.

The lime-sulphur compounds are not suitable fungicides for grapes, the self-boiled because it does not control the rot, and the commercial lime-sulphur because it does not control the rot as well as the Bordeaux mixture and is very injurious to the vines.

Of the adhesive compounds used, the results with resin-fishoil soap were better than those with the iron sulphate. The addition of 2 pounds of soap to 50 gallons of the mixture used in the last application seems to do as much good as where it is added in all sprayings.

The disease can be controlled with five applications of 4-3-50 Bordeaux mixture thoroughly applied, soap being used in the last application. "Thoroughly applied" means that every portion of the vine, and especially the foliage and fruit, receives a coating of spray mixture.

Approved:

JAMES WILSON,

Secretary of Agriculture.

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